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Study of Corrosion of 1100 Aluminum

A study was initiated to determine the corrosion of 1100 aluminum in oxygen-saturated water at 70°C under various experimental conditions. The effects of exposure interruption, the number of specimens, and the refreshment rate were studied.

The water used for the corrosion tests was of high purity (less than 50 ppb impurities). Oxygen was bubbled through it until it was saturated. Up to eight extruded 1100 aluminum rods were suspended on Pyrex glass hangers and immersed in the oxygen-saturated water. The temperature maintained in the test chamber was $70^\circ \pm 1^\circ\text{C}$.

In a test of long duration, two chambers were used in series with refreshment (oxygen-saturated) water passing through each in turn. In this case, the rate of water flow was 15 cc/min for the first 5 days and 7 cc/min thereafter. However, in some tests the rate of flow was increased to over 60 cc/min to determine the effect of the refreshment rate.

Tests were conducted for periods of nearly 1000 days. In some cases, specimens were temporarily removed to determine the effect of exposure interruption. Also, the number of sample rods used in each test was varied from one to eight to determine what effect the amount of aluminum surface area had on the rate and amount of corrosion.

The amount of corrosion was determined by an eddy current thickness gage which is insensitive to the oxide coating (corrosion). The change in the induction properties of a coil is used as a function of the thickness of uncorroded metal placed within it. When properly calibrated, the gage measures the thickness of uncorroded metal to an accuracy of $\pm 25 \text{ \AA}$.

As a result of the study the following conclusions were reached:

1. The amount of corrosion during the first 7 hours of exposure is proportional to the logarithm of time. Exposure interruptions during the first 48 hours resulted in a substantial reduction in subsequent corrosion rate (as compared to continuous exposure); however, interruptions after the first several days of a test resulted in no discernible effect to the corrosion rate.
2. The number of specimens caused wide variances in the corrosion rate. Substantially more corrosion occurred per specimen in the chamber containing more corroding metal (more specimens), indicating that a product of the corrosion reaction contaminates the water and increases the corrosion. This was further indicated by the effect of the refreshment rate. Higher flow rates diluted the contaminant that increases corrosion, reducing the rate of corrosion. In the case where a second test chamber was used, the corrosion rate was higher since contaminated water flowed into the second chamber while clean water flowed into the first chamber.
3. During longer test periods, the initial corrosion was logarithmic and was followed by an increase in rate and by a subsequent extended period of logarithmic reaction. From this it is assumed that the surface of the test sample develops a periodic logarithmic growth and breakdown of a protective oxide film. The breakdown is caused by a corrosion product (hydrogen) which builds up enough pressure under the film to rupture it. Each time the breakdown of protective film occurs, the initial rate of reaction is less than that preceding the break. The total amount of corrosion occurring in each cycle is the same; consequently, the duration of succeeding cycles is longer.

(continued overleaf)

4. On the basis of the test information, a corrosion rate expression was derived that fits the known observations. The derivation is a simple logarithmic equation of the form

$$L = K_1 + K_2 \ln t$$

where L is the amount of metal corroded and t is time.

Notes:

1. References: *Jour. Electrochem. Soc.* vol. 110, no. 6, June 1963. *Corrosion*, vol. 19, no. 8, p. 269t-271t, August 1963. *Corrosion*, vol. 19, no. 5, p. 165t-168t, May 1963. *Jour. Electrochem. Soc.* vol. 114, 352, 353 (1967).

2. Inquiries concerning this innovation may be directed to:

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Patent status:

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